

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

In the Claims:

1. (currently amended) An image forming device that forms an image on a print paper in an ink jet recording method with a plurality of heads, comprising:

main scanning direction moving means for moving a carriage in a main scanning direction, said carriage having said plurality of heads mounted thereon;

paper conveying means for conveying the print paper in a sub-scanning direction;

pattern printing means for printing, with at least one head, a test pattern including predetermined pattern elements;

pattern detecting means, mounted on said carriage, for detecting the pattern elements of the test pattern printed on the print paper by said printing means;

binary conversion means for binarizing an output of said pattern detecting means;

position detecting means for detecting a position of the carriage in said main scanning direction; and

calculating means for moving said carriage to detect the pattern elements of the test pattern with said pattern detecting means, for detecting a print position of the pattern elements based on a detection result of said position detecting means when a rising and/or falling edge of a binary signal obtained by said

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

binary conversion means is generated, and for calculating a mounting deviation amount of each head in said main scanning direction,

wherein said position detecting means comprises low-resolution position detecting means based on a linear scale provided on a movement path of said carriage and high-resolution position detecting means for detecting a high-resolution position more than twice as finely than as a minimum unit determined by a resolution of said low-resolution position detecting means such that said low-resolution position detecting means and said high-resolution high-resolution position detection means are combined with each other to precisely detect the positions of the pattern elements.

2. (previously amended) The image forming device according to claim 1 wherein, for each head, said test pattern is at least one vertical bar extending in the sub-scanning direction substantially perpendicular to said main scanning direction.

3. (previously amended) The image forming device according to claim 1, wherein said test pattern includes, for each head and as a pattern element, at least one horizontal bar extending substantially in parallel with said main scanning direction, further comprising:

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

conveyance amount detecting means for detecting a conveyance amount of the print paper in the sub-scanning direction substantially perpendicular to said main scanning direction; and measuring means for measuring the conveyance amount equal to or smaller than a minimum unit determined by a resolution of said conveyance amount detecting means,

wherein said calculating means moves the print paper, on which the test pattern is printed, with the use of said paper conveying means with respect to the carriage to detect the pattern elements of the test pattern with said pattern detecting means, detects the print position of the pattern elements based on the detection results of said conveyance amount detecting means and said measuring means when a rising and/or falling edge of the binary signal obtained by said binary conversion means is generated, and calculates an amount of mounting deviation of each head in said sub-scanning direction based on the print position of the pattern elements printed by each head.

4. (previously amended) The image forming device according to claim 1 wherein said pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

5. (previously amended) The image forming device according to claim 1 wherein said low-resolution position detecting means

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

comprises a counter for counting a timing signal based on said linear scale and wherein said high-resolution position detecting means comprises a timer which is initialized by said timing signal and measures a time with a predetermined clock signal.

6. (previously amended) An image forming device that forms an image on a print paper in an ink jet recording method with a plurality of heads, comprising:

main scanning direction moving means for moving a carriage in a main scanning direction, said carriage having said plurality of heads mounted thereon;

paper conveying means for conveying the print paper in a sub-scanning direction;

pattern printing means for printing, with at least one head, a test pattern including predetermined pattern elements;

pattern detecting means, mounted on said carriage, for detecting the pattern elements of the test pattern printed on the print paper by said printing means;

binary conversion means for binarizing an output of said pattern detecting means;

position detecting means for detecting a position of the carriage in said main scanning direction; and

calculating means for moving said carriage to detect the pattern elements of the test pattern with said pattern detecting means, for detecting a print position of the pattern elements

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

based on a detection result of said position detecting means when a rising and/or falling edge of a binary signal obtained by said binary conversion means is generated, and for calculating a mounting deviation amount of each head in said main scanning direction,

wherein said position detecting means comprises low-resolution position detecting means based on a linear scale provided on a movement path of said carriage and high-resolution position detecting means for detecting a position more finely than a minimum unit determined by a resolution of said low-resolution position detecting means such that said low-resolution position detecting means and said ~~high-resolution~~ high-resolution position detection means are combined with each other to precisely detect the positions of the pattern elements,

wherein, for each head, said test pattern is at least one vertical bar extending in the sub-scanning direction substantially perpendicular to said main scanning direction, and

wherein said pattern printing means causes each of different portions of a single head to print a plurality of dots sequentially in a plurality of passes, said plurality of dots constituting a portion of said vertical bar.

7. (previously amended) The image forming device according to claim 1 wherein said calculating means uses said pattern detecting means to detect the vertical bar in at least two

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

positions in a longitudinal direction of said vertical bar to obtain a print position of said vertical bar based on an average value of the detected results.

8. (original) The image forming device according to claim 5, further comprising:

means for measuring a unit time interval of said linear scale at a time said pattern elements are detected; and

means for correcting a measured value of said timer based on the measured value and a theoretical value of said unit time interval.

9. (previously amended) An image forming device that forms an image on a print paper in an ink jet recording method with a plurality of heads, comprising:

main scanning direction moving means for moving a carriage in a main scanning direction, said carriage having said plurality of heads mounted thereon;

paper conveying means for conveying the print paper in a sub-scanning direction;

pattern printing means for printing, with at least one head, a test pattern including predetermined pattern elements;

pattern detecting means, mounted on said carriage, for detecting the pattern elements of the test pattern printed on the print paper by said printing means;

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

binary conversion means for binarizing an output of said pattern detecting means;

position detecting means for detecting a position of the carriage in said main scanning direction; and

calculating means for moving said carriage to detect the pattern elements of the test pattern with said pattern detecting means, for detecting a print position of the pattern elements based on a detection result of said position detecting means when a rising and/or falling edge of a binary signal obtained by said binary conversion means is generated, and for calculating a mounting deviation amount of each head in said main scanning direction,

wherein, for each head, said test pattern includes as a pattern element at least one vertical bar extending in the sub-scanning direction substantially perpendicular to said main scanning direction, and

wherein said pattern printing means divides said vertical bar into a plurality of portions and causes each of different portions of a single head to print a plurality of dots sequentially in a plurality of passes, said plurality of dots constituting a portion of said vertical bar.

10. (previously amended) The image forming device according to claim 1 wherein, based on both edges of an obtained

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

pattern element, said calculating means calculates a center position of a width of the pattern element.

11. (currently amended) A method, for use on an image forming device with a linear scale provided on a carriage movement path, for detecting a deviation between a print position actually printed on a print paper by a head and a print target position, said method comprising the steps of:

providing a timer for detecting a high-resolution position within a unit interval determined by a resolution of said linear scale;

printing a predetermined print element at the target position on the print paper by the head mounted on a carriage that scans in a main scanning direction;

detecting said print element with a sensor mounted on said carriage;

when the print element is detected by said sensor, detecting a low-resolution position based on said linear scale and, detecting a high-resolution position within the unit interval with said timer more than twice as finely as a minimum unit determined by a resolution of said low-resolution position; and

obtaining the deviation between a position detected by combining said low-resolution position detection with said high-resolution position detection and said print target position.

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to Office action of June 16, 2003

12. (original) The method according to claim 11, further comprising the step of correcting the high-resolution position within the unit interval, which was detected by said timer, based on an actual measurement value measured in a minimum unit interval of said linear scale and a theoretical value thereof.

13. (original) The image forming device according to claim 2 wherein said pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

14. (original) The image forming device according to claim 3 wherein said pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

15. (original) The image forming device according to claim 2 wherein said low-resolution position detecting means comprises a counter for counting a timing signal based on said linear scale and wherein said high-resolution position detecting means comprises a timer which is initialized by said timing signal and measures a time with a predetermined clock signal.

16. (previously amended) The image forming device according to claim 6 wherein said calculating means uses said pattern detecting means to detect the vertical bar in at least

Appl. No. 09/937,858
Amdt. dated September 16, 2003
Reply to office action of June 16, 2003

two positions in a longitudinal direction of said vertical bar to obtain a print position of said vertical bar based on an average value of the detected results.

17. (original) The image forming device according to claim 9 wherein, based on both edges of an obtained pattern element, said calculating means calculates a center position of a width of the pattern element.